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MANUFACTURE, COMPOSITION, AND UTILIZATION OF DAIRY BYPRODUCTS FOR FEED

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INTRODUCTION

The production of concentrated and dried buttermilk, skim milk, and whey on a commercial scale was made possible by two conditions: (1) Scarcity, high prices, and need for commercial feedstuffs during the World War; and (2), the establishment of central creameries, which assured a large and steady supply of buttermilk. The potential feed value of these byproducts, which to a large extent were being wasted, had been recognized long before, but the cost of preparing a feed from them far exceeded the price of other feeds of equal feeding value. During the World War, condenseries and drying plants sprang up all over the dairy districts. Thus a new industry, the dairy byproducts industry, was established.

The development of this industry was materially assisted by the favorable reports made by numerous investigators, largely experiment station workers, who demonstrated the high feed value of dairy products. These byproducts have now found a firm place on the market as valuable feeds for poultry and livestock.

According to figures compiled by the Bureau of Agricultural Economics, Department of Agriculture, the total production of creamery butter in 1933 was 1,762,688,000 pounds. The equivalent yield of buttermilk was approximately 2,644,032,000 pounds. (One and one-half pounds of buttermilk is produced to every pound of butter.) The amounts of condensed buttermilk and dried buttermilk produced in the United States in 1933 were estimated to be 50,175,000 and 53,260,000 pounds, respectively. The remainder of the raw buttermilk was fed on the farm or wasted. In the same year 288,114,000 pounds of dried skim milk were manufactured.

Foods and feeds have been manufactured from the byproducts of creameries for about 15 years. During that time there has been a

growing demand for them by poultrymen, animal husbandmen, bakers, ice-cream manufacturers, and to a limited extent by other industries. As a result of dairy byproducts being prepared in a marketable form, a larger number of milk-fed chickens are on the market.

DAIRY BYPRODUCTS DEFINED¹

The following definitions have been adopted by the Association of American Feed Control Officials (*1, p. 15, 21*).¹

Evaporated Buttermilk (Feeding), Concentrated Buttermilk (Feeding), Condensed Buttermilk (Feeding), is the product resulting from the removal of a considerable portion of water from clean, sound buttermilk derived from natural cream to which no foreign substances have been added excepting such as are permitted and necessary in the manufacture of butter. It contains not less than 27 percent total solids, not less than 2 percent butterfat, and not more than 0.14 percent ash for each percent of solids. This definition does not prohibit the use of a distinctive trade name, provided it is followed by one of the names given.

Dried Skimmed Milk (Feeding) is the product resulting from the removal of water from clean, sound skimmed milk. It contains not more than 8 percent moisture.

Condensed Skimmed Milk (Feeding) is the product resulting from the removal of a considerable portion of water from clean, sound skimmed milk. It contains not less than 27 percent total solids.

Dried Buttermilk (Feeding) is the product resulting from the removal of water from clean, sound buttermilk derived from natural cream, to which no foreign substances have been added, excepting such as are necessary and permitted in the manufacture of butter. It contains not more than 8 percent moisture, not more than 13 percent mineral matter (ash), and not less than 5 percent butterfat, as determined by the Roesse-Gottlieb method.

Dried Soured Skimmed Milk (Feeding) is the product resulting from the removal of water from clean, sound skim milk which has been soured by a suitable culture of lactic bacteria. It contains not more than 8 percent moisture.

Milk Sugar Feed, Dried Whey (Feeding) is the byproduct from the manufacture of cheese and should contain at least 70 percent lactose (milk sugar).

Evaporated Soured Skimmed Milk (Feeding), Concentrated Soured Skimmed Milk (Feeding), Condensed Soured Skimmed Milk (Feeding) is the product resulting from the removal of a considerable portion of water from the clean, sound skim milk which has been soured by a suitable culture of lactic bacteria. It contains not less than 27 percent total solids.

DRIED BUTTERMILK

Any creamery producing 1,000,000 pounds of butter annually can profitably dry or condense its own buttermilk. The condensing or drying plant is usually located next door to the central creamery. A pipe line from the churns to storage tanks in the drying or condensing plant affords a convenient arrangement for delivering the liquid buttermilk. However, many creameries find it more profitable to sell their buttermilk to other condensing or drying plants.

The acidity of the cream at the time of churning influences the character of the buttermilk produced. Before sour cream is made into butter, the lactic acid is generally neutralized by calcium hydrate or sodium carbonate to 0.2 percent free acid, as that acidity is believed by most butter makers to make the best flavored butter. More neutralizer is used in summer than in winter. The neutralizer materially affects the composition of the resulting buttermilk.

The effect on the composition of the buttermilk of the neutralizers added to the cream is shown in table 1 by the high ash content and the consequent low lactose figure. Attention is called to the data on moisture. When stored, dried buttermilk with a low moisture con-

¹ Italic numbers in parentheses refer to literature cited, p. 15.

tent attracts atmospheric moisture and becomes lumpy. The table also shows the composition of buttermilk made from cream to which no neutralizer had been added. In this buttermilk the moisture and ash are low, and the lactose is high. In the last few years buttermilk made from sweet cream, which differs somewhat in composition from that made from sour cream, has been condensed and dried, chiefly for food purposes.

TABLE 1.—*Analyses of dried buttermilk (roller process)*¹
MADE FROM CREAM TO WHICH NEUTRALIZER HAD BEEN ADDED

Sample no.	Moisture	Fat	Protein	Ash	Lactose	Lactic acid
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
50887.....	7.41	2.85	31.44	14.20	8.17	7.07
50888.....	7.81	2.75	33.13	14.26	7.10	6.93
50889.....	7.57	5.68	32.25	12.29	15.45	4.41
50890.....	9.37	5.60	31.38	12.40	23.73	4.46
50891.....	9.49	7.09	34.25	10.96	13.47	4.60
50892.....	7.58	5.53	30.38	10.13	13.19	3.72
50897.....	7.88	4.80	33.31	14.23	9.00	8.55
50898.....	8.64	9.29	34.06	12.21	9.00	8.93
50899.....	11.69	5.75	30.38	12.61	20.28	5.48

MADE FROM CREAM TO WHICH NO NEUTRALIZER HAD BEEN ADDED

52104.....	4.89	4.72	32.50	10.75	25.34	6.00
52107.....	4.54	9.08	34.00	11.76	22.55	3.16
52108.....	6.86	5.32	33.19	8.22	31.66	2.69
52109.....	4.61	6.60	32.75	9.08	32.01	4.14
52129.....	4.90	.59	34.94	7.79	42.17	1.30
52130.....	5.72	6.00	33.13	10.78	27.25	4.28
52131.....	4.98	2.16	32.50	8.92	41.13	.77
52132.....	4.75	1.59	35.50	10.72	26.48	4.69
52134.....	2.52	4.06	34.31	10.68	26.39	4.37
52140.....	3.73	5.98	32.94	10.37	33.05	3.21
52141.....	5.24	4.94	31.00	8.72	34.24	3.58
52142.....	4.61	5.48	31.63	9.96	33.34	3.39
52143.....	4.37	4.28	30.63	9.37	35.20	3.86
52144.....	4.29	7.36	32.81	9.12	29.46	4.04
52145.....	6.19	5.49	34.31	10.11	28.32	4.32
52146.....	4.48	6.30	32.75	8.78	33.34	4.18
52165.....	4.89	.68	33.75	9.67	30.89	4.15
52370.....	4.58	5.14	32.19	8.94	35.19	-----

¹ In tables 1 to 4, inclusive, fat determinations were made with sulphuric ether in the Goodrich-Knorr apparatus. Protein, ash, lactic acid, and moisture determinations were made by the methods of the Association of Official Agricultural Chemists (2). These data on lactose were obtained by the picric acid method devised by Coe (7). The results agree as closely as can be expected with those obtained by the copper-reduction method.

CONDENSED BUTTERMILK

Before buttermilk is condensed, its acidity is increased from about 0.25 to about 1.5 percent, calculated as lactic acid, either by the action of bacteria naturally present or by a starter, usually *Bacillus bulgaricus*. In the former case the optimum acidity is produced in 2 to 4 days; in the latter, 2 days is generally sufficient. To make a smooth product for condensing, the buttermilk is stirred during the ripening process.

When the acidity has reached at least 1.5 percent, the liquid buttermilk is raised to tanks known as hot wells. Live steam is introduced into the liquid until the temperature is near the boiling point. This operation not only heats the buttermilk but also keeps it agitated. The heated buttermilk is delivered from the hot well to the vacuum

pan (figs. 1 and 2) through a pipe. It remains in the vacuum pan (fig. 1) until it is reduced to one-fourth of its original volume, which requires about 8 hours. The condensed buttermilk is then removed through an opening in the bottom of the pan and stored in barrels

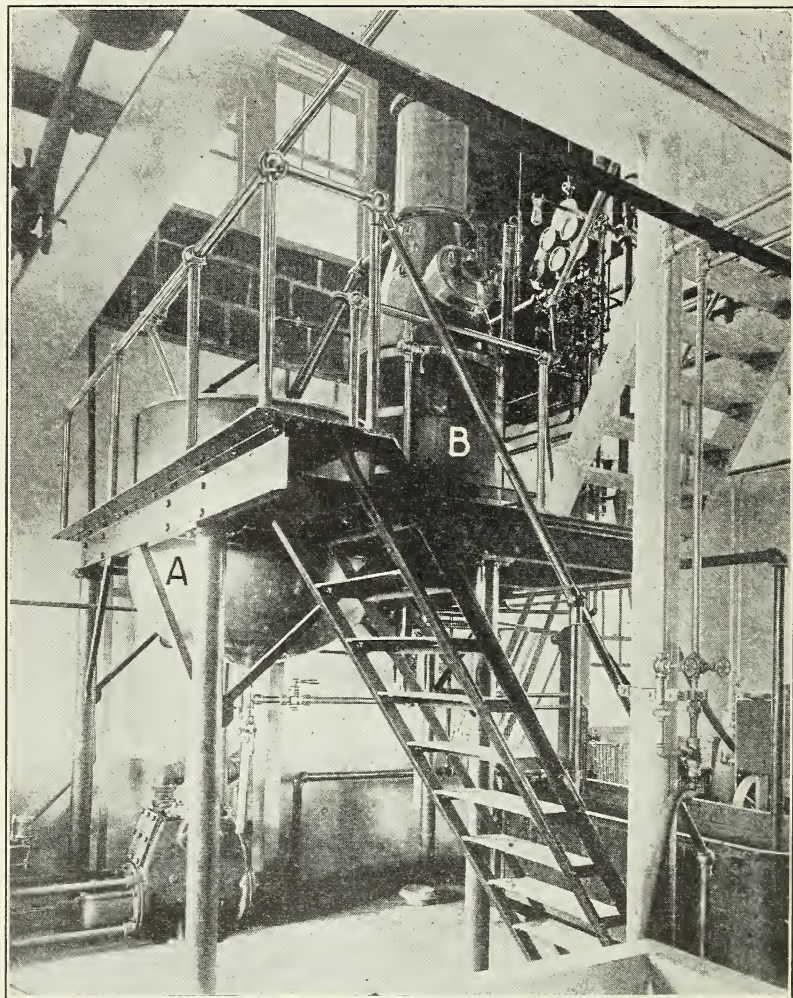


FIGURE 1.—Condensing outfit: A, hot well; B, vacuum pan.

that hold as much as 300 pounds. When cool, it has the consistency of paste and generally has a creamlike color.

When the condensed buttermilk is made for food, glass-lined tanks and sanitary piping must be used.

Condensed buttermilk was found to be so profitable when sold as a feed that dairymen and ice-cream manufacturers of the East have applied the same general process to their surplus skim milk.

The oversupply of milk in dairies comes in the spring and summer. At that time the milk is separated, and most of the cream is sold to city customers. The surplus is generally sold to ice-cream factories. The skim milk is condensed or evaporated and sold to bakeries and ice-cream factories. If there is more skim milk than can be disposed of in this form, it is soured with a lactic-acid culture and converted into so-called condensed buttermilk. The least profit is made on this manufactured buttermilk.

The season of oversupply is different when an ice-cream factory is combined with a dairy plant. In this case, the time of surplus begins in September and lasts until June. In summer, the large volume of milk is taken care of by the large sales of ice cream. In winter, when ice-cream consumption is low, the surplus skim milk is converted into so-called condensed buttermilk.

Although, strictly speaking, the product made from skim milk is not buttermilk, it approaches buttermilk in composition and feed value. It has the same lactic acid content and practically the same protein content. The only difference in the manufacture is that usually skim milk is evaporated to one-third its original volume instead of one-fourth as is buttermilk. Table 2 shows the similarity in the composition of condensed buttermilk and condensed skim milk.

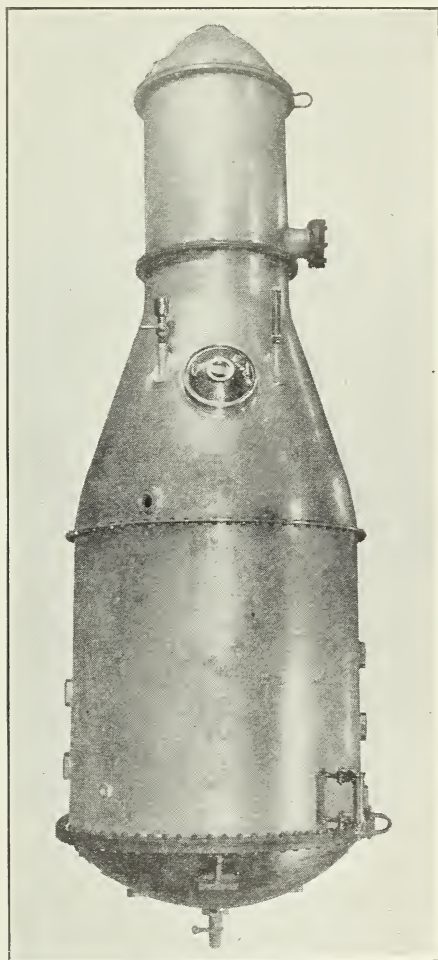


FIGURE 2.—Vacuum pan.

TABLE 2.—Analyses of condensed buttermilk and condensed skim milk

Sample no.	Product	Moisture	Fat	Protein	Ash	Lactose	Lactic acid
		<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
50900.....	Condensed buttermilk....	67.53	5.15	12.63	4.12	2.20	5.49
52383.....	do.....	62.44	2.81	13.19	6.80	10.95	4.15
F. C. 158-c.....	do.....	75.50	4.02	9.38	3.08	3.86	2.41
50902.....	Condensed skim milk....	71.80	6.62	11.00	3.20	.38	7.32
50903.....	do.....	69.77	4.10	12.13	2.74	5.72	5.25
50904.....	do.....	71.69	3.04	9.13	2.30	9.27	4.17

The keeping quality of condensed buttermilk made either from skim milk or buttermilk depends on its high acid content, which averages between 4 and 6 percent. If the acid content is less, the condensed buttermilk is likely to putrefy and become unfit for feed. Another form of spoilage found in condensed buttermilk is said to be due to the lime which is added to the cream as a neutralizer. The product in this case becomes grainy and occasionally contains formations resembling finger coral.

Condensed buttermilk is usually sold direct to the farmer.

MANUFACTURE OF DRIED BUTTERMILK AND DRIED SKIM MILK

The manufacture of dried buttermilk and dried skim milk is increasing. This increase is due not only to their great merit as feeds for poultry and young stock, but also to their extensive use in bakeries and ice-cream factories. Besides, these dried products are convenient to ship, to store, and to mix with other feeds. They should be stored however, in a dry place, since they take up moisture readily. Excessive moisture may cause spontaneous combustion.

In table 3 analytical data on buttermilk powders are tabulated according to the color of the product. As the color of the dried buttermilk turns from light cream to brown there is a tendency for both the ash and the acid figure to increase, and the lactose figure to decrease. The color is produced during drying by the action of the neutralizer on the lactose.

TABLE 3.—Analyses of dried buttermilk samples tabulated according to color from light cream to dark brown

Sample no.	Color	Time made	Moisture	Fat	Protein	Ash	Lactose	Lactic acid ¹	Remarks
			Percent	Percent	Percent	Percent	Percent	Percent	
52144	Light cream	March	4.29	7.36	32.81	9.12	29.46	4.04	Roller process, sour cream.
52131	About the same	do	4.98	2.16	32.50	8.92	41.13	.77	Roller process, sweet cream.
52051	Shade darker	February	6.01	6.00	31.69	10.30	24.36	3.07	Roller process, sour cream.
52374	3 shades darker	March	6.09	6.74	32.69	12.06	25.33	4.79	Do.
52375	1 shade darker	do	5.83	1.28	26.44	11.87	33.31	5.39	Do.
50892	do	June	7.58	5.53	30.38	10.13	13.19	3.72	Do.
52052	A little darker	February	5.45	5.00	33.63	14.54	13.12	5.53	Do.
47813	Shade darker	March	6.49	13.86	33.56	9.35	14.40	8.09	Roller process, semisolid and liquid buttermilk.
50897	Slightly darker	June	7.88	4.80	33.31	14.23	9.00	8.55	Spray process (Rogers), sour cream.
50887	2 shades darker	do	7.41	2.85	31.44	14.20	8.17	7.07	Roller process, sour cream.
50898	Shade darker	do	8.64	9.29	34.06	12.21	13.19	8.93	Roller process, semisolid and liquid buttermilk.
52069	do	Summer	7.72	6.74	32.38	13.17	13.47	6.09	Do.
50891	do	June	9.49	7.09	34.25	10.96	13.47	4.60	Do.
50896	do	do	8.76	5.28	33.56	13.32	7.73	9.54	Spray process, sour cream.
52373	do ²	March	7.02	7.21	27.81	12.72	21.20	5.07	Roller process.
50895	do	June	8.42	7.96	34.25	14.17	23.90	11.12	Spray process, sour cream.
50899	3 shades darker	do	11.69	5.75	30.38	12.61	20.28	5.48	Roller process, sour cream.
52371	Very dark brown	December	7.53	8.00	34.88	12.49	12.32	6.88	Roller process, much heated.

¹ Based on 8 percent solids.² Due to heating.

Dried buttermilk is manufactured throughout the year, but the largest output occurs from April to November, the peak being reached during June and July. When dried buttermilk first came on the market, it was manufactured during the spring and summer, and then stored from November to April. Now, the demand generally exceeds the supply, and it is sold as soon as it is made.

In the far West, where creameries are few, skim milk is dried and used as feed, whereas in the East comparatively little dried skim milk is used as feed on account of the demand for it as human food.

Dried buttermilk is made by the roller process, the spray process, or by a combination of the two.

THE ROLLER PROCESS

Until recently 90 percent of the entire output of dried buttermilk was made by the roller process. At first sour buttermilk was used as the raw product, but lately dried buttermilk has been made from sweet-cream buttermilk.

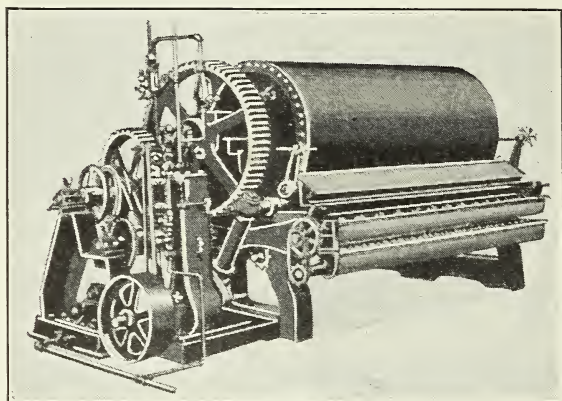


FIGURE 3.—Machine used in making dried buttermilk by the roller process.

In the roller process used by most manufacturers (fig. 3) no condensing previous to drying is necessary. The raw buttermilk is run into a trough under the roller, being continuously agitated to keep it from lumping. It is pumped from the trough and sprayed on a steam-heated revolving roller which makes about two revolutions per minute. The temperature of the product reaches about 190° to 200° F. The thin film of dried buttermilk that forms on the roll is removed automatically by a stationary sharp knife. The dried buttermilk is still slightly moist when it comes off the roll, but it dries to about 4 percent moisture while being transferred by a screw conveyor to receiving bins. Sometimes the buttermilk is condensed first and then sprayed on the roller. The dried product ranges in color from cream white to dark brown.

THE SPRAY PROCESS

In one spray process for making dried skim milk (fig. 4) the skim milk passes from the storage tanks to sieves, which remove any particles that might clog the spray point. It is then sprayed under pres-

sure into a chamber along with heated air which has first been filtered by screened windows, then by dust collectors arranged in accordion-like tiers inside the building. This filtered air is forced through a heating chamber having steam-heated coils which raise its temperature to about 190° F. Exhaust steam is used when available.

The skim-milk powder falls to the floor and is removed through holes in the bottom of the floor. The chamber must be cleaned thoroughly each night, otherwise the milk powder remaining turns brown and spoils any future run, making the product fit only for feed purposes. The moisture is carried off with the moving heated air, which is led through linen bags arranged in an upright position in an adjoining chamber to catch any suspended particles of milk powder. The air then escapes through an 8-inch pipe to the outside of the building.

No. 1 grade skim-milk powder is used by bakeries, ice-cream factories, etc.; no. 2 grade, which includes floor sweepings and the discolored product from the drying chamber, is disposed of as feed.

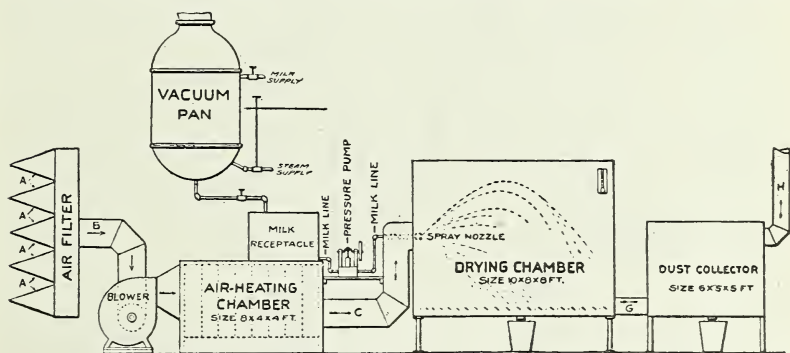


FIGURE 4.—Skim-milk drier, spray process.

In a later process the liquid milk is pumped from the main storage tank to one placed near the ceiling, the quantity of milk in the latter being controlled by a float valve. A round chamber, tapered at the bottom and much larger than the tank at the ceiling, is placed below and at one side. Connecting the two is a pipe line with a spray nozzle at the outlet end. The milk under pressure is sprayed into the large chamber, and falls as a fine light-colored powder containing about 5 percent moisture. This process has also been used for making dried buttermilk.

In another spray process, used for making dried buttermilk, the drying chamber, unlike either of the two used in the processes described for skim milk, is oblong and has a V-shaped bottom on which the dried buttermilk collects. A horizontal screw conveyor removes the powder to a hopper.

In still another spray process (fig. 5), in use in the Middle West, the skim milk or buttermilk is first condensed. Then it is sprayed into a cubical chamber tapered at the bottom like a reversed pyramid. By this process, which dries the product to about 3 percent moisture, skim-milk powder is produced in three grades of fineness. These

are mixed together and sold to bakers. All dried milk which collects in the corners of the apparatus and in the dusters is swept out and sold to local farmers at a sufficiently low price to encourage them to bring their milk to the plant. The portion sold for feed amounts to about 4 percent. Usually 8 pounds of dried skim milk are produced from 100 pounds of liquid. The same yield is obtained from buttermilk. Table 4 shows the analyses of dried milk products made by the various processes.

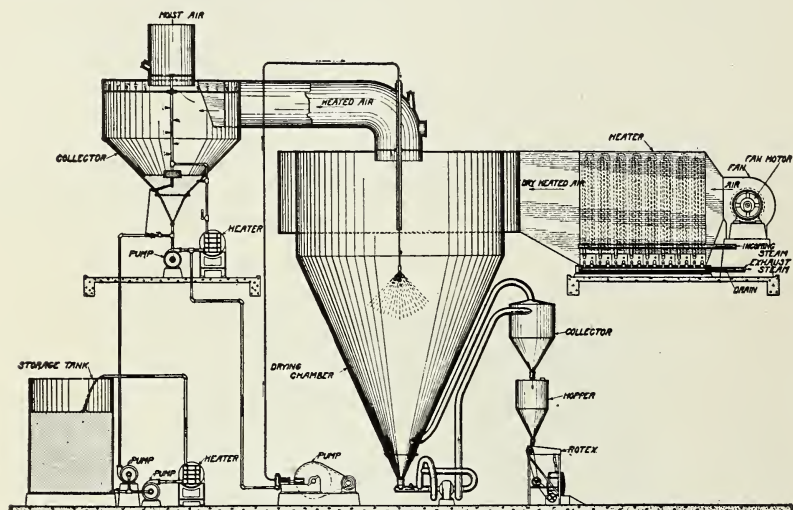


FIGURE 5.—Skim-milk drier, spray process.

TABLE 4.—Analyses of some dried milk products on the market

Sample no.	Product	Moisture	Fat	Protein	Ash	Lactose	Lactic acid	Remarks
50863	Dried skim milk.	Percent 7.44	Percent 0.65	Percent 36.75	Percent 20.60	Percent 3.21	Percent 0.23	Roller process. Used for baby food.
50884	do	5.92	9.12	36.06	7.33	37.98	1.35	Spray process. Sweepings and discolored portion. Used for feed.
50885	do	6.45	.25	31.88	7.80	47.03	1.63	Roller process. Used for baking purposes.
50886	do	6.33	8.60	31.69	7.18	38.63	1.21	Roller process. Used for feed.
50879	do	6.54	.28	33.44	7.55	44.02	1.86	Spray process. Used for food.
50880	do	7.04	.36	31.44	7.84	45.83	1.75	Spray process. Floor sweepings after 24 hours' run. Used for feed.
50881	do	6.87	.16	32.94	7.78	43.07	2.00	Do.
50882	do	3.67	.01	30.69	8.35	49.01	1.91	Spray process. Used for food.
48620	do	4.60	.14	34.25	7.91	47.92	1.67	Roller process. Used for food.
52070	Dried whole milk.	2.78	25.27	23.94	5.90	31.62	1.30	Do.
47813	Dried buttermilk.	6.49	13.86	33.56	9.35	14.40	8.09	Roller process. Made from semisolid and liquid buttermilk. Used for feed.
50898	do	8.64	9.29	34.06	12.21	9.00	8.93	Roller process. Used for feed.
50895	do	8.42	7.96	34.25	14.17	23.90	11.12	Spray process. Cleanings from 24 hours' run. Used for feed.
50896	do	8.76	5.28	33.56	13.42	7.73	9.54	Spray process. Good grade. Used for feed.
50894	do	4.65	3.28	32.75	8.53	37.53	4.69	Spray process. Used for feed.

Excessive moisture content of dried milk results in relatively rapid deterioration of the product; hence the tendency in recent years has been toward the manufacture of a product of lower moisture content. It seems probable therefore that dried milks, especially the dried skim milks, are at present of an average lower moisture content than those discussed here.

WHEY

Whey is a liquid residue produced in the manufacture of cheese. Whey produced at the small factories (fig. 6) is, with few exceptions, given to the farmers for feeding purposes. Sometimes in the summer there is an excess, which is thrown away.

As a result of investigations by Clickner (12) and the Kraft-Phoenix Cheese Co., as well as by the United States Bureau of Dairy Industry,

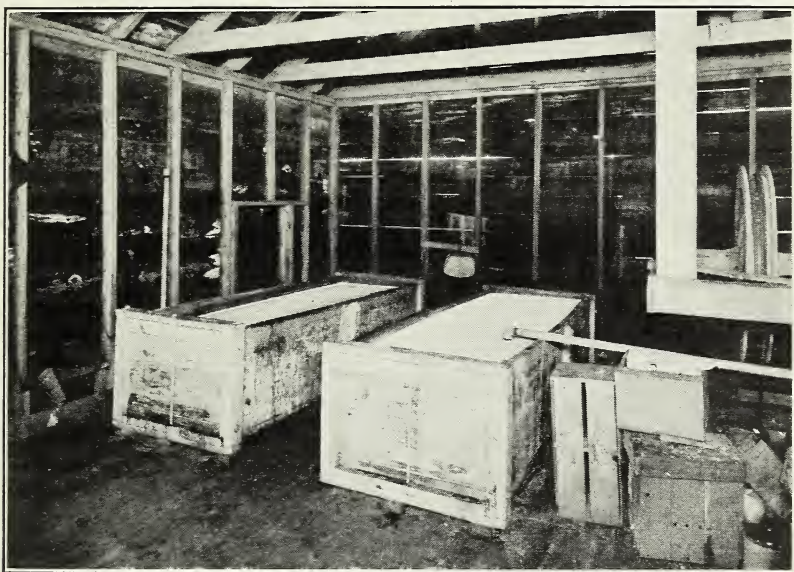


FIGURE 6.—Whey tanks at a cheese factory.

thousands of tons of so-called milk-sugar feed or dried whey have been made available for feed.

The output of whey from many factories is too small for drying, since the undried whey contains only about 4 percent of solids. The cost of drying, apart from the cost of installing a drying plant, would necessitate charging a price for the dried product which would be far in excess of that of other dairy byproducts. Only centralized cheese factories find it profitable to conserve this residue.

Hanke (12) states that, as with other dairy byproducts, excellent results have been obtained with whey used as an ingredient of mixed feeds.

Harding (13) declares that concentrated whey used as a feed produces highly satisfactory results in growth and health. He suggests that the potent nutritional substances of milk may be found in the milk serum or whey. He also states that the minerals in whey, such as calcium and phosphorus, are in a form that makes them easy to

assimilate. Numerous feeding experiments have shown that whey constitutes a valuable feed for pigs, poultry, calves, and other farm animals.

Analyses of whey solids are given in table 5.

TABLE 5.—Average composition of whey solids ¹

Fat	Protein	Ash	Lactose	Undetermined
<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
3.76	12.55	7.19	69.18	7.32
4.04	12.81	6.54	68.69	7.92
2.37	12.86	7.64	71.22	5.91
3.39	12.74	7.12	69.70	7.05

¹Determined by Berry (4).

NUTRITIONAL VALUE OF DAIRY BYPRODUCTS FOR FEED

The use of dairy byproducts as feed for poultry and stock is well-known. When the ration includes as little as 5 percent of either dried or condensed buttermilk, dried or soured and condensed skim milk, or whey (liquid or dried), a beneficial influence is obtained, as has been shown by numerous feeding experiments. There can be no question that the substances in milk byproducts are of exceptional value in nutrition.

Both lactose and lactic acid are reputed to be of value in combating bacillary white diarrhoea and coccidiosis in poultry. Lactose, it seems, favors the development of lactic acid producing bacteria in the intestines. The resulting conditions suppress the putrefactive bacteria which are said to be responsible for many diseases. Carrick (5) is of the opinion that lactic acid is also beneficial, by acting as a tonic in stimulating the consumption of feed and water.

As far back as 1915, Rettger (17) found that sweet and sour milk are apparently of equal value in producing growth and reducing mortality of chicks. Later Beach and Davis (3), working with pure lactose, and Carrick (5), working with pure lactic acid, found that they were equally effective in combating bacillary white diarrhoea or coccidiosis. In fact, Beach has demonstrated that lactose is the control factor in milk byproducts when used for these purposes.

Associated with lactose are the milk proteins and the milk minerals. According to Hart (15), milk proteins are "without question of the highest quality and the most easily digested proteins used in feeding." In fact, they have a mutually supplementary effect when fed with grains because the necessary amino acids, such as cystine and tryptophane, are present, while those missing in milk products are found in the grains. Milk proteins, consequently, make a very good supplement to the proteins in grains and their byproducts. Carrick (5) states that under normal conditions milk proteins are almost completely digested and absorbed. Although milk proteins are too costly for the main source of proteins, they are undoubtedly practical supplements for other protein concentrates.

Milk byproducts are all rich in minerals, notably compounds of calcium and phosphorus, in a form easily assimilated. This is of importance to the feeder in view of the recent knowledge concerning

the role of minerals in the early stages of growth, especially for stock prepared for the market. Table 6 gives the average analyses of the ash of whole-milk powder produced in New York and Wisconsin and intended for human consumption (20). It is quite probable that milk powder used for feed would not differ from these appreciably. On the other hand, the ash of dried buttermilk would differ on account of varying amounts of neutralizer that might be added.

TABLE 6.—*The average ash content of whole-milk powder produced in New York and Wisconsin*

[Results expressed as percentages on moisture-free powder basis and on the ash basis]

State	Ash	P ₂ O ₅		Cl		CaO		MgO	
		Powder	Ash	Powder	Ash	Powder	Ash	Powder	Ash
New York.....	7.678	2.035	26.50	1.041	13.55	1.708	22.24	0.187	2.44
Wisconsin.....	7.647	2.084	27.50	.962	12.58	1.707	22.32	.193	2.52

State	K ₂ O		Na ₂ O		SO ₃		Undeter- mined (ash ba- sis)	O-Cl equiva- lent (ash basis)
	Powder	Ash	Powder	Ash	Powder	Ash		
New York.....	2.047	26.70	0.548	7.14	0.172	2.24	2.24	3.05
Wisconsin.....	2.139	27.97	.469	6.13	.172	2.25	1.80	2.82

The ash of milk does not truly represent the mineral content, however, because during the process of incineration, the character of some of the constituents is altered by oxidation and otherwise. According to Van Slyke and Bosworth (21), the constituents are probably combined in the forms shown in the following tabulation:

<i>Constituent</i>	<i>Percent</i>
Fat.....	3.90
Lactose.....	4.90
Proteins combined with calcium.....	3.20
Dicalcium phosphate (CaHPO ₄).....	.175
Calcium chloride (CaCl ₂).....	.119
Monomagnesium phosphate (MgH ₄ P ₂ O)103
Sodium citrate (Na ₃ C ₆ H ₅ O ₇).....	.222
Potassium citrate (K ₃ C ₆ H ₅ O ₇).....	.052
Dipotassium phosphate (K ₂ HPO ₄).....	.230
Total solids.....	12.901

Milk is a good source of vitamins A, B, and G, and it also contains small quantities of vitamin C. The vitamin content of milk by-products varies with the process used for concentrating as well as with the original vitamin content of the milk. According to Eddy (9), Ellis and MacLeod (10), Funk (11), and Sherman and Smith (19), neither the fat-soluble A nor the water-soluble B vitamins in milk are noticeably affected by evaporation or drying. Since the fat has been removed, milk byproducts ordinarily fed to poultry and stock are low in the fat-soluble vitamins. On the other hand, most of the water-soluble vitamins B and G remain. Mendel (16) states that milk is now being dried without serious loss of any of the three vitamins A, B, and C. Johnson (14) also found that drying skim milk by the spray process does not injure the water-soluble vitamins. Cavanaugh

(6) and his associates indicate that the spray process of drying milk preserves vitamin C in its original strength.

No experimental data seemed to be available on the vitamin content of buttermilk products until Sherman (18) in his recent article emphasized the value of vitamin G. He says:

The most important source of vitamin G is milk; as this is a water-soluble vitamin most of it goes into the skim milk and buttermilk in butter-making, or into the whey in cheese-making.

The discovery of vitamin G and of its great importance as a nutrient, and therefore, as a factor in food values, shows skim milk to have a much higher food value than has previously been assumed.

Recent investigational work at some of the State experiment stations and at the United States Animal Husbandry Experiment Farm at Beltsville, Md., has indicated that at least a part of the beneficial effect of milk products in nutrition is due to the presence of vitamin G.

Milk byproducts are exceptionally valuable for the feeding of young stock of all kinds. Calves, swine, horses, rabbits, and dogs show sturdy and healthy growth when milk products are added to the ration. Eckles and Gullickson (8) in experiments with condensed and powdered buttermilk found that on the buttermilk ration calves made excellent growth and were unusually free from sickness and digestive troubles.

According to the opinion of various experiment station investigators consulted by the author, the use of from 5 to 20 percent of dairy byproducts in a ration will produce marked improvement in growth and in the general health of fowls or stock and in the egg production of the former. In many instances the addition of as little as 5 percent of milk products will appreciably increase the hatchability of the eggs produced. This is especially true when the diet is composed essentially of cereal grains and their byproducts.

SUMMARY

Dairy byproducts for feed purposes are on the market in the form of condensed and dried buttermilk, condensed and dried skim milk, and dried whey. Tests have shown that each of these products has excellent feeding value and health-giving and mortality-reducing properties. All dairy byproducts are highly digestible feeds. When fed to poultry they assist in combating bacillary white diarrhoea. When they are used in feeds for young stock, sturdy and healthy growth results.

Dairy byproducts are beneficial to poultry and farm animals because they are good sources of protein of high quality, vitamin G, and mineral salts. They also contain lactose, which in addition to supplying energy is held to be a factor in the prevention of intestinal diseases. There is also some evidence that lactose and lactic acid may have other properties aside from their nutritive value. As a source of protein, ordinary meat scraps are cheaper, but the difference in price is offset by the beneficial results obtained by feeding dairy byproducts, especially in the early stages of growth when gains are most desirable. Experiment station investigators engaged in feeding experiments state that from 5 to 20 percent of dairy byproducts may be advantageously mixed with other feeds.

The various processes of manufacturing dairy byproducts are described, and analyses of dairy byproducts are given.

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